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Aquaculture systems & farming systems: inside, outside or side-by-side?

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1 Introduction

Two main approaches have been used as regard to aquaculture systems design. The first one considers aquaculture as an integral part of the farming system, as it is the case for most traditional aquaculture systems that have been designed over the centuries in a deep integration with the surrounding crop and animal production (Edwards, Little, & Demaine, 2002). However, not all aquaculture systems fit within this category. Over the centuries, aquaculture ponds have also sometimes been perceived in isolation, or even as a competitor to agriculture development, occasionally leading to their draining and destruction (Billard, 2010). Many modern technologies have also been promoted in a relative isolation from their agricultural surroundings, either because they were soilless or implemented in natural environments (lakes or marine areas, mangroves etc.). For this kind of technology, the system design has been more towards understanding the interactions with their socio-ecological system. This presentation and paper will review several case studies in order to contribute to its formulation.

2 Aquaculture, a component of the farming systems or a component of the socio-ecological systems?

Aquaculture is a millenary activity and over the centuries, highly efficient and integrated aquaculture systems emerged globally (Edwards *et al.*, 2002; FAO, 2003; D. Nhan *et al.*, 2007). They have been advocated to increase land & water use efficiency as well as nutrient recycling (D. K. Nhan, Milstein, Verdegem, & Verreth, 2006). One of the most famous is probably the Vietnamese VAC (*Vuon, Ao & Chuong* meaning garden/pond/livestock pen in Vietnamese) that combines a multi-fish-species pond with a garden producing vegetables or fruits, and livestock supplying organic fertilizers (Luu, 2003). Its widespread promotion started in the 1980s and two models developed: the upland VAC system, which is generally larger (garden: 1000-15000 m^2) and more extensive than the lowland model (garden: 200-300 m^2). Edwards (1998) developed a FSD framework comprising three interrelated aspects: production technology, social and economic aspects, and environmental aspects to describe such integrated aquaculture-agriculture systems. Studies have however pointed out their complexity of management, as the pond sub-system not only requires good management practices to maximize benefits to farmers while minimizing environmental impacts, but also implies to be integrated as much as possible with existing farming activities to maximize production while minimizing nutrient discharges (D. K. Nhan *et al.*, 2006).
The need for a system approach describing and understanding this kind of aquaculture also emerged among development practitioners, as a result of the necessity to better understand and propose technologies to fit to farmer's needs. In Africa, FSD approach including an aquaculture component was proposed in Ivory Coast, within the framework of a development project conducted in the Midwestern region (Dabbadie *et al.*, 1994). In such cases, the aquaculture system is just a sub-component of the farming system, similar to the livestock or crop systems but with its own technical and economical specificities. Considering the socio-economical conditions prevailing in the country at the end of the 1990s (Léonard & Oswald, 1995), aquaculture was a good candidate for agriculture diversification and two models emerged, based on FS diagnostics: one semi-intensive close to urban centers based on fish polyculture combining species with supplementary feeding habits (tilapia, catfish, *Heterotis niloticus*, *Hemichromis fasciatus*) and rice bran feeding + fertilization, and another one located in rural area where access to inputs was almost impossible (Dabbadie, 1996). The production was extensive but quantitatively important, by making use of very large ponds obtained by building drainable dams across valleys and stocking them at a very low fish density (Dabbadie, 1996).
But aquaculture has not always emerged as a component of farming systems, particularly in recent decades. It has also colonized new ecosystems, such as mangroves (Primavera, 2005), lakes (De Silva & Davy, 2010), coastal areas (GESAMP, 2001) and even, the open-sea (Troell *et al.*, 2009). In such areas, the systemic studies have rather considered the ecological (habitat destruction, eutrophication etc.) and social system (conflicts for resources among users, collective action and decision making) but not the farming system.

3 Conclusion

In reality, modern globalized aquaculture can never be considered in complete isolation. Even the fish produced offshore are for example largely fed with agricultural products, originating from existing farming systems sometimes on a global scale. Feed used in Vietnamese pangasius aquaculture often contains American soybeans, for example. On the other side, society demands for a better consideration of the social and environmental impacts of aquaculture. A new

FSD for aquaculture, capable of dealing with all dimensions of modern aquaculture on both the local and global scale, is thus required and the framework proposed by Ostrom (2009) could serve as a basis for this purpose. In the aquaculture-dominated Pampanga delta (Philippines), a territorial approach has been developed in a systemic manner by combining remote sensing, GIS and field analysis (Mialhe, Gunnell, Mering, & Dabbadie, 2011). By showing the spatial organization of subsystems, it has evidenced the main drivers of changes. It could serve as a basis for further FSD research and development on aquaculture systems.

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